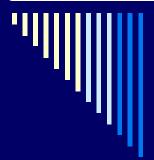


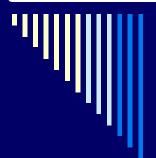
Back to the future of video compression

Touradj Ebrahimi @epfl.ch



It's all about representation

- From a keynote by M. Vetterli at ICIP2004:
 - 256x256 pixels, 24 bits/pixel=2^(256x245x24)
 (D. Field)
 - All images on the internet
 - □ 5-50 billion or 33 to 36 bits
 - All pictures taken in the history of mankind (M. Vetterli)
 - □ 100 years: 10¹⁰ circa 44 bits
 - Learn from nature
 - 20 bits/sec processed by the human brain (D. Gabor)
 - Current state of the art
 - □ JPEG: 200 Kbytes
 - □ JPEG 2000: 30% better in average
 - There is still a lot of room for improvements



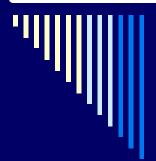
Time-Space-Frequency representations

- 1D: Time-Frequency representation:
 - DCT, sub-band, wavelets, ...
 - MP3, AAC
- 2D: Space-Frequency representation:
 - 2D separable DCT (MPEG, JPEG, ITU-T)
 - 2D separable wavelets (MPEG, JPEG, ITU-T)
- □ 3D: Time-Space-Frequency representation
 - Straightforward 3D separable extension (Karlsson et al.)
 - Mainly hybrid schemes adopted in state of the art
 - Motion compensated 3D extension (Jens et al.)
 - Basis of Scalable Video Coding



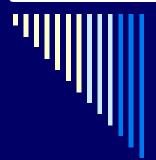
New representation methods

- Non-linear approximation
 - Sub-space depends on the signal to be decomposed
 - Take the M largest coefficients versus the first M coefficients
 - $A(x+y)\neq A(x)+A(y)$
- Non-separable decomposition
 - Geometric transforms



Extensions to wavelets

- Signal adapted schemes
 - Bandelets [LePennec & Mallat]: wavelet expansions centered at discontinuity as well as along smooth edges
 - Non-linear tilings [Cohen, Mattei]: adaptive segmentation
 - Tree structured approaches [Shukla et al, Baraniuk et al]



Extensions to wavelets

- Bases and frames theory
 - Wedgelets [Donoho]: Basic element is a wedge
 - Ridgelets [Candes, Donoho]: Basic element is a ridge
 - Curvelets [Candes, Donoho] Scaling law: width ~length²
 - Contourlets and Multidirectional pyramids [Do et al] Discrete-space
 - Directional wavelet transforms and frames [Velisavljevic et al]



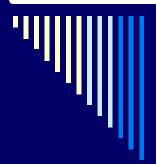
Extensions to wavelets

- Coping with discontinuities:
 - Fourier is not good for singularities
 - Wavelets are good for point singularities
 - X-lets are good for curve and line singularities
- Rate of convergence
 - Fourier: O(M^{-1/2})
 - Wavelet: O(M⁻¹)
 - Contourlet: O(M⁻²)



Open questions

- How much does it cost to completely code an xlet representation
 - Lessons learned from region/object based representation
- How to apply x-lets on 3D (video=space+time) and how much gain
 - Lessons from 3D subband decomposition of video
- □ How much gain comes from the choice of x-lets as transform block versus the rest of compression scheme (quantization, entropy coding)?
 - JPEG proposed AMD



JPEG proposed AMD

- □ There is an attempt to replace wavelet transform by DCT in JPEG 2000
- Rationale:
 - The 30% average gain in compression comes from entropy coding
 - Lossless transcoding from and to JPEG
 - Existing products based on a similar approach (Stufflt)



Is there a Moore's law of compression?

- The compression efficiency doubles every five years
 - H.263 twice better than H.261
 - MPEG-4 AVC part 10 (H.264) twice better than MPEG-4 version 1
- Developments on future directions in video compression will show if such a law exists